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YALE UNIV NEW HAVEN CONN MASON LAB
EXPERIMENTAL AND THEORETICAL STUDY OF CONDENSATION BY HOMOGENEO--ETC(U)
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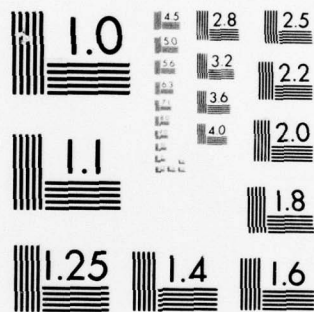
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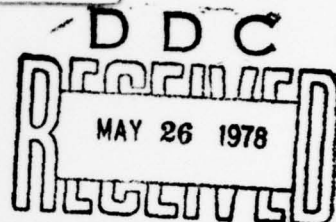
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DEPARTMENT OF ENGINEERING
AND APPLIED SCIENCE

Mason Laboratory
9 Hillhouse Avenue

22 Dec 1977



TO: Power Program, ONR Code 473

FROM: (10) Peter P. Wegener, Principal Investigator

SUBJECT: (15) Annual Summary for Contract N00014-75-C-0263
(6) Experimental and theoretical study of condensation
by homogeneous and binary nucleation.

PERIOD: Calendar year 1977.

GENERAL REMARKS:

During the calendar year 1977 the listed publications and presentations were produced. Finally, the monograph on "Gas dynamics and Homogeneous Nucleation", appeared in the volume Nucleation Phenomena (ed. Zettlemoyer), Elsevier 1977. Dr. W.J. Dunning from Bristol University visited and close cooperation between us and Drs. M. Hoare, P. Pal and J.A. Barker was initiated. This group at Bedford College, London provided for us cluster energies and other thermodynamic data for argon.

RESULTS:

The shock tube work by C.F. Lee on condensation of five vapors was completed. In the process several new techniques were developed which saw their completion in 1977. For one, the light scattering system was improved to give the quantitatively expected change of light intensity for condensation based on Rayleigh scattering calculations versus time at a given location. Moreover, the gasdynamic problems due to finite opening of the diaphragm, etc. were removed by the technique of applying a "virtual origin", shifted with respect to the original origin of the centered expansion fan, in which condensation takes place. Finally, cooling rates were observed that were in between those found in either cloud chambers or nozzles. A smaller supercooling was observed, in particular, in water at lower cooling rate as expected.

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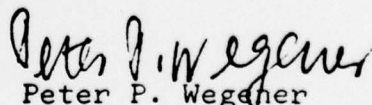
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The new condensation data included water (at different cooling rates and temperatures), heavy water, benzene, carbon tetrachloride, and Freon-11. The experimental onset conditions of the various substances studied generally agreed with previous findings in supersonic nozzles, shock tubes and diffusion cloud chambers for those materials for which data are available. No substantial difference was found in the onset conditions for water and heavy water, both being well predicted by the classical theory. The properties entering nucleation rate and growth differ only slightly between the two substances and this result is not surprising. The classical theory holds if the vapors are supposed to nucleate as supercooled liquid droplets in a range to about -45°C . The classical theory was also found to hold for nucleation of benzene if the condensate is assumed to be a solid at temperatures of -50 to -70°C . Carbon tetrachloride was also found to follow the classical theory assuming it to be a solid appreciably below the melting point. As found before by the MIT Group, Freon-11, however, appears to nucleate at a much higher rate than that predicted by the classical theory. We are still looking into possible experimental causes that may have effected this nucleation rate such as binary nucleation, etc.*

Our theoretical work concentrated on attempts to incorporate argon cluster calculations provided by the previous papers of McGinty, and Hoare and Pal into rate theory. For one, it was found that a comparison of the McGinty and Hoare results, obtained by different techniques, shows remarkable agreement between the two. Here the cluster energies are computed for argon by statistical thermodynamics based on known inter-atomic potentials. In addition new data provided by Hoare and Pal to our group in a range of conditions for which we have experimental results on argon, could moreover be interpolated to produce results for Gibbs energy of cluster formation along particular isentropes. Thus nucleation rates in the classical framework could be computed by dropping the capillarity assumption and replacing it by energies produced by calculations of the cluster mechanics. The results of these calculations were found to qualitatively agree with experiment, and this work is now being pursued in greater detail.


Peter P. Wegner

* It is recalled that chloroform nucleation data were previously masked by such effects.

ONR Reports 1977

- #35 Benjamin J.C. Wu, "Analysis of Condensation in the Centered Expansion Wave in a Shock Tube," (January 1977).
- #36 C.F. Lee, "Condensation of H₂O and D₂O in Argon in the Centered Expansion Wave in a Shock Tube," (January 1977).
- #37 C.F. Lee, "An Experimental Investigation of the Critical Supersaturation of Five Vapors in a Shock Tube," (in process).

JOURNAL PAPERS 1977

- Peter P. Wegener and Benjamin J.C. Wu, "Gasdynamics and Homogeneous Nucleation," Advances in Colloid and Interface Science, pp. 325-417, Nucleation Phenomena, ed. A.C. Zettlemoyer. Elsevier Scientific Publishing Company, New York 1977.
- B.J.C. Wu, "Analysis of Condensation in the Centered Expansion Wave in a Shock Tube", pp. 73-82, Condensation in High-Speed Flows, ed. A.A. Pouring, ASME, New York, 1977.
- C.F. Lee, "Condensation of H₂O and D₂O in Argon in the Centered Expansion Wave in a Shock Tube," pp. 83-96, Condensation in High-Speed Flows, ed. A.A. Pouring, ASME, New York 1977.
- C.F. Lee, "An Experimental Investigation of the Critical Supersaturation of Five Vapors in a Shock Tube," Doctoral Dissertation submitted to the Graduate School, Yale University, 1978.

INVITED PRESENTATIONS 1977

- 31 March, Peter P. Wegener, "Experimental Methods in Nucleation Studies", EUROMECH 88, Two-Phase Flow Systems with Condensation Phenomena, Karlsruhe, Germany.
- 4 April, Peter P. Wegener, "Condensation by Homogeneous Nucleation", Dept. of Physics, Bedford College, University of London.
- 16 June, B.J.C. Wu, "Analysis of Condensation in the Centered Expansion Wave in a Shock Tube", Joint Applied Mechanics, Fluids Engineering and Bioengineering Conference, The American Society of Mechanical Engineers, New Haven, Connecticut.
- 16 June, C.F. Lee, "Condensation of H₂O and D₂O in Argon in the Centered Expansion Wave in a Shock Tube", Joint Applied Mechanics, Fluids Engineering and Bioengineering Conference, The American Society of Mechanical Engineers, New Haven, Connecticut.
- 23 May, Peter P. Wegener, "Condensation Research: An Overview", NASA Langley Laboratory.

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